

Development of MPGDs with resistive foils in JAPAN

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Background of development

- ▶ Some Japanese researcher have interested to MPGD with resistive material
- ▶ Problems to start R&D
 - It is difficult to make uniform resistive layer
 - There are resistive foil in commercial (on catalogue), but it is difficult to get it
 - Strategic items?
- ▶ CERN got the resistive Kapton from Dupont
 - R. Oliveira provide me a few tenth sheet of the foil
 - Last November
- ▶ I will report the current development status of resistive MPGD (using Rui's Kapton)

Development Items using resistive Kapton

- ▶ GEM readout with resistive Kapton
 - KEK (S.Uno)
 - No micro patterning process
- ▶ GEM with resistive Kapton electrodes
 - RIKEN (T. Tamagawa) and CNS (S. Hamagaki)
 - Laser drilling (SciEnergy co. Ltd.)
- ▶ μ -PIC with resistive cathodes
 - Kobe Univ. (A. Ochi)
 - Wet etching (Raytech inc.)
- ▶ These works are activities of MPGD fundamental R&D group in Japan.

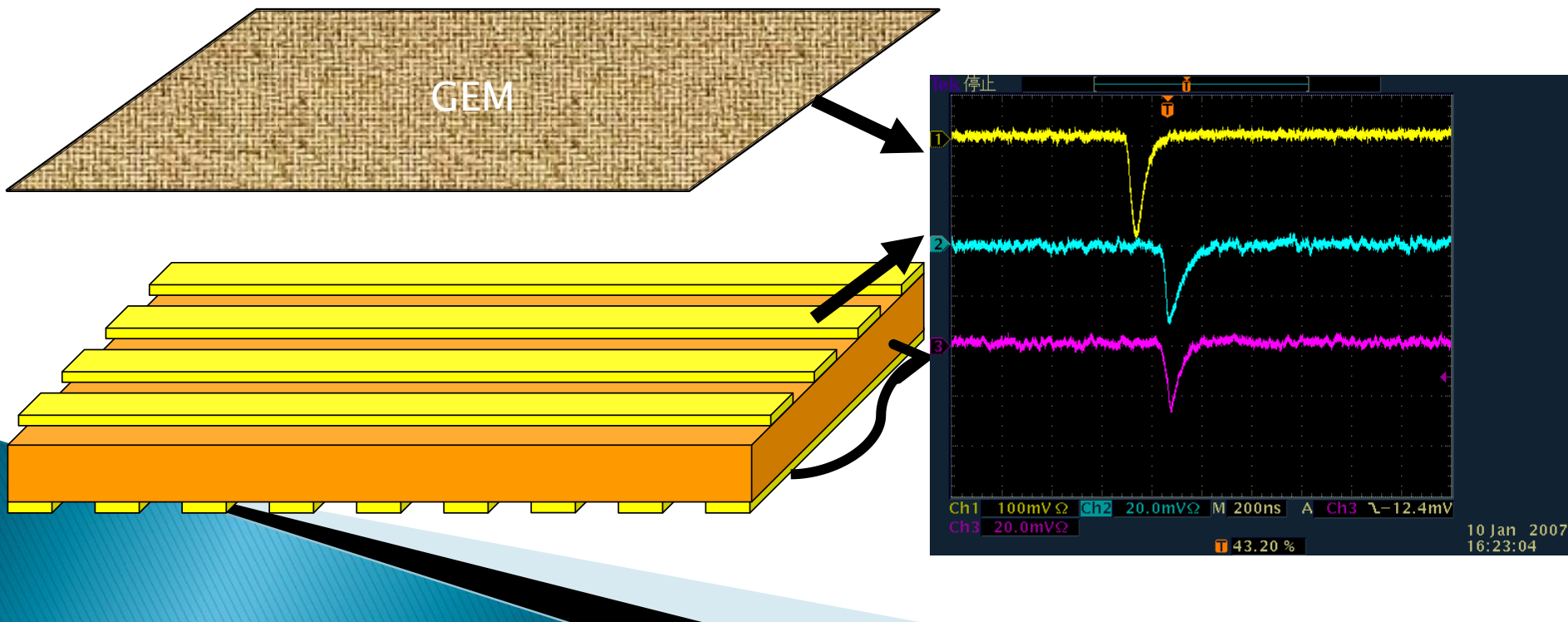
GEM readout with resistive material

» KEK MPGD group

GEM readout in KEK

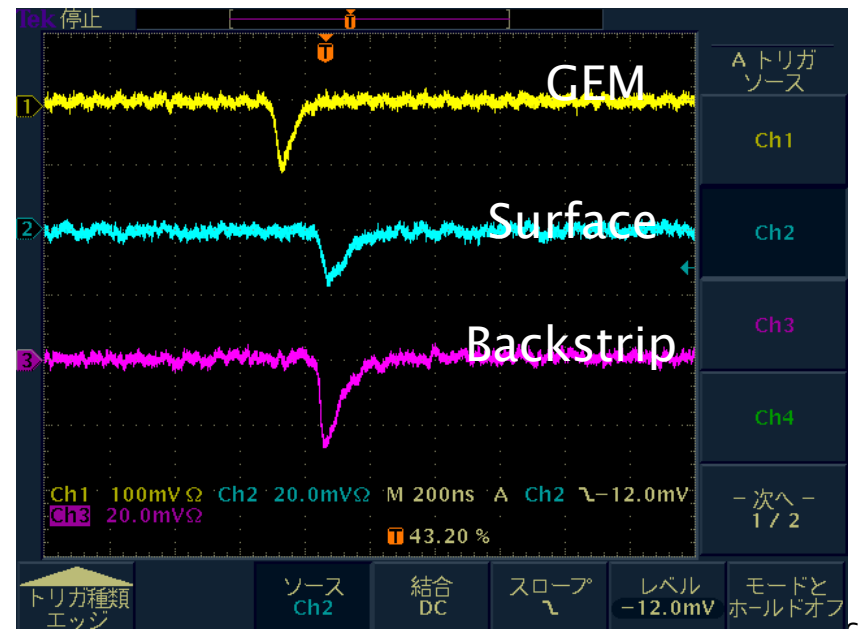
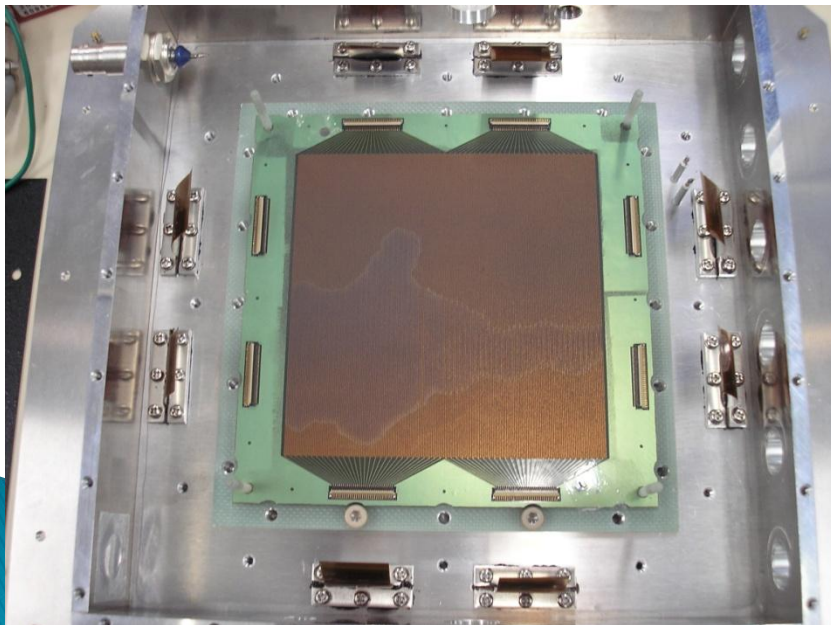
X,Y Strip (Double sided)
Strip pitch 0.8mm
Number of strips 120×120
Area 96mm×96mm

- ▶ Inverse signals were found from backstrip
- ▶ It goes to normal when small surface conductivity attached (by water)
- ▶ Well controlled surface conductivity was required



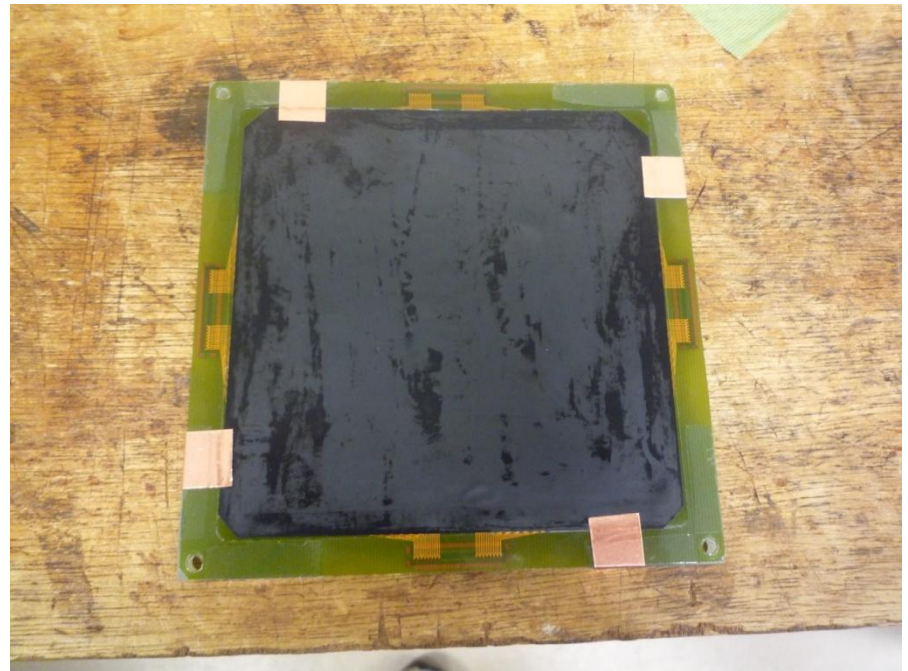
First trial of resistive coating

- ▶ Carbon splaying on the readout board
 - Carbon + plastic + methyl acetate
 - Thickness : $5\mu\text{m}$
 - Surface resistivity : $\sim 10\text{M}\Omega/\text{square}$
 - But difficult to control
 - Efficiency was not uniform

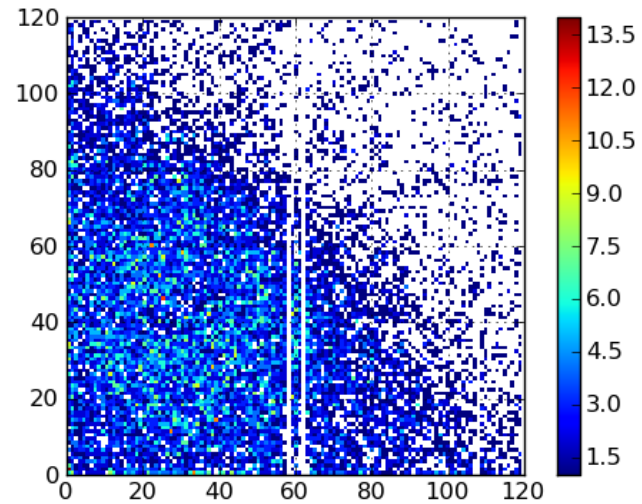
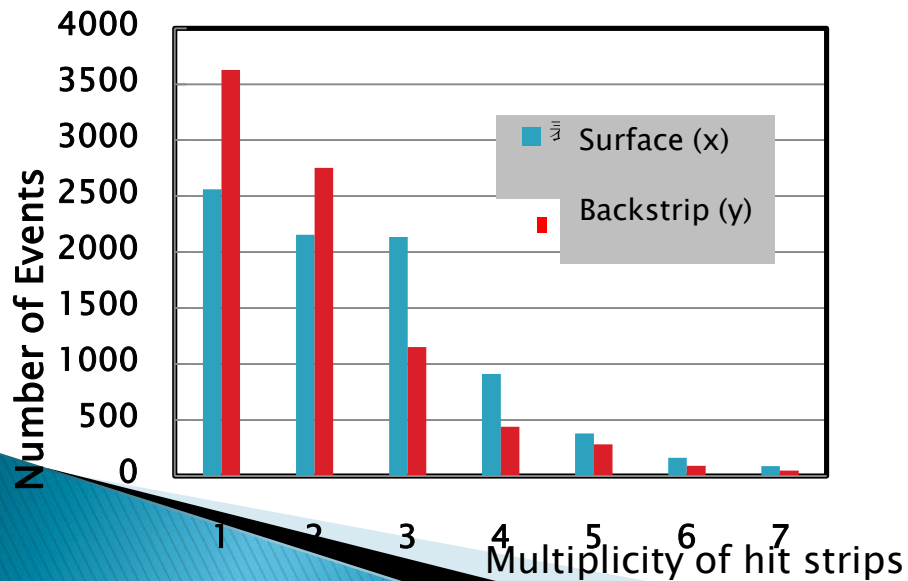
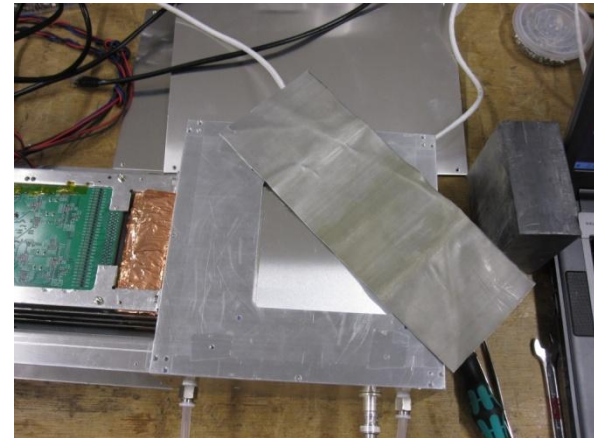
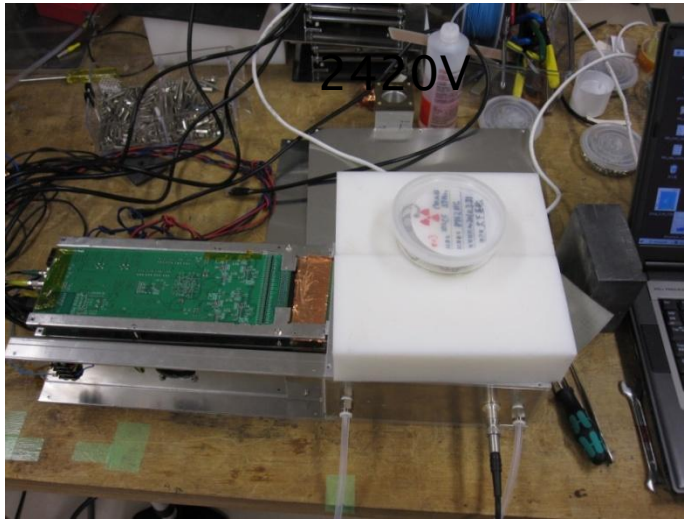


Using resistive Kapton

- ▶ Put the resistive Kapton on double sided readout board
- ▶ Silicon rubber was used for attachment
 - There is no micro pattern process on resistive kapton
- ▶ 2 stage GEM with Boron cathode was used for neutron imaging



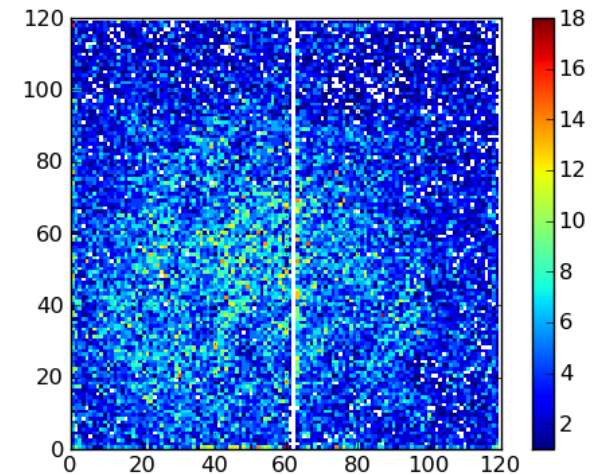
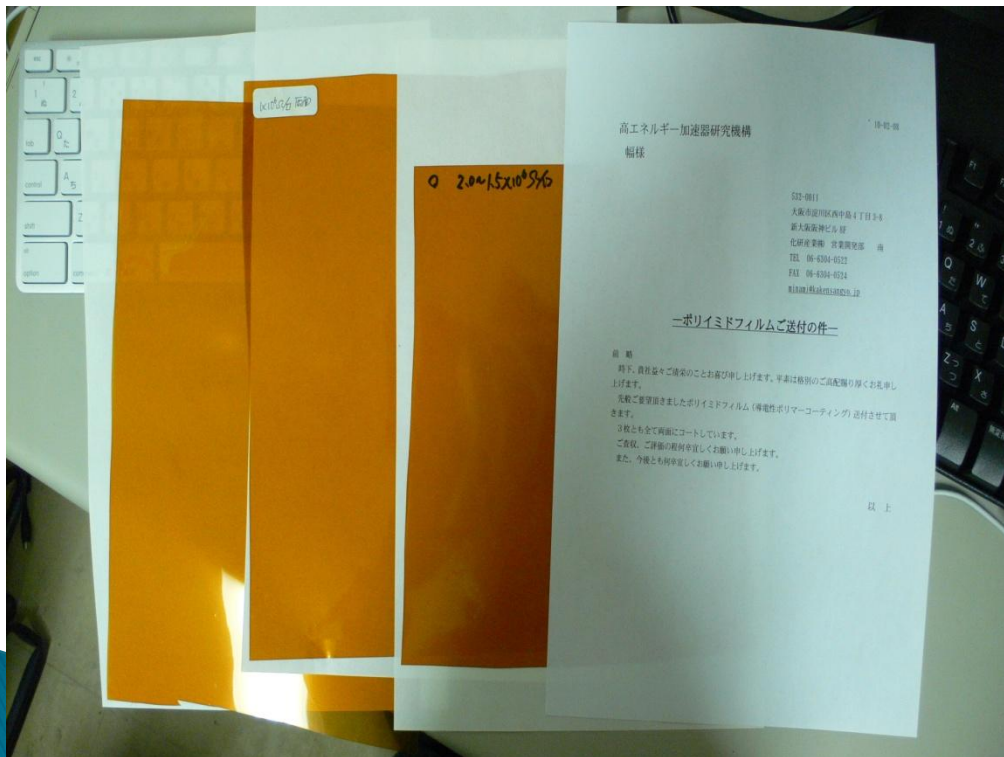
Neutron image and charge distrib.



► HV : 2420V, Coincidence fraction : 55%

Further trial for using resistive foil

- ▶ Polyimide with conductive polymer coating
 - (Kaken Industry co. Ltd)
 - Surface resistance: $\sim 20\text{M}\Omega/\square$



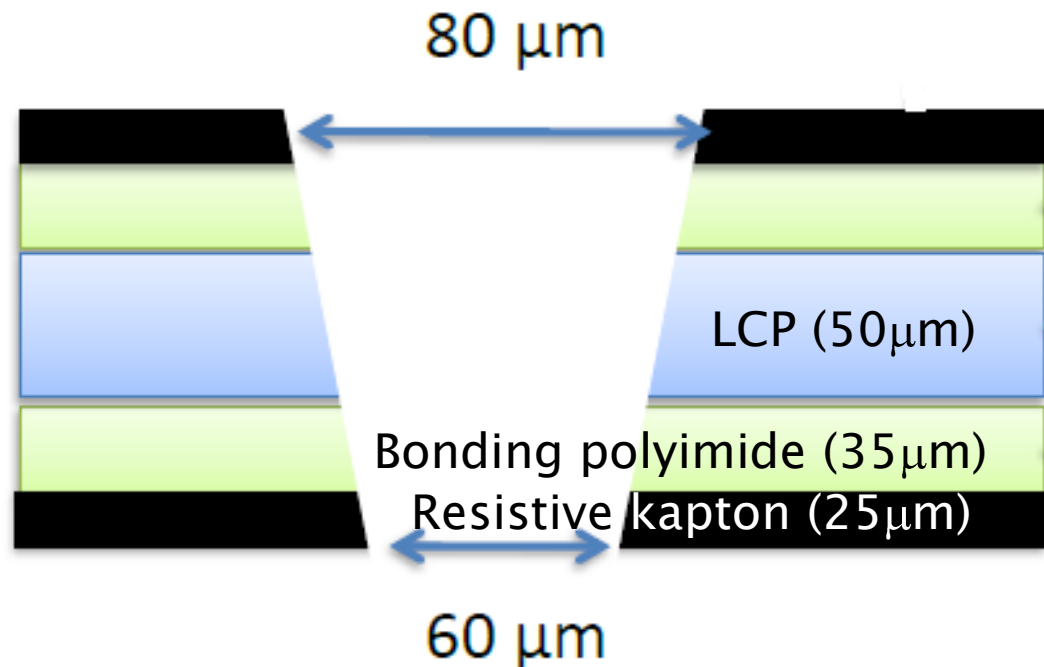
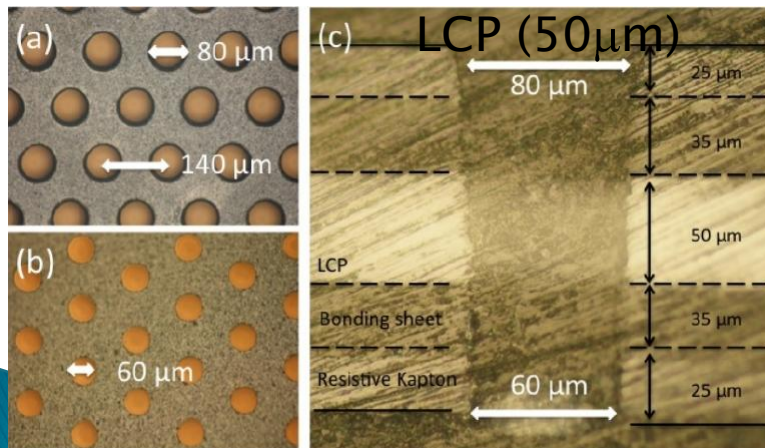
- ▶ HV : 2420V,
- ▶ Coincidence fraction 53%

GEM with resistive kapton electrode

» RIKEN / CNS (Univ. Tokyo)
group

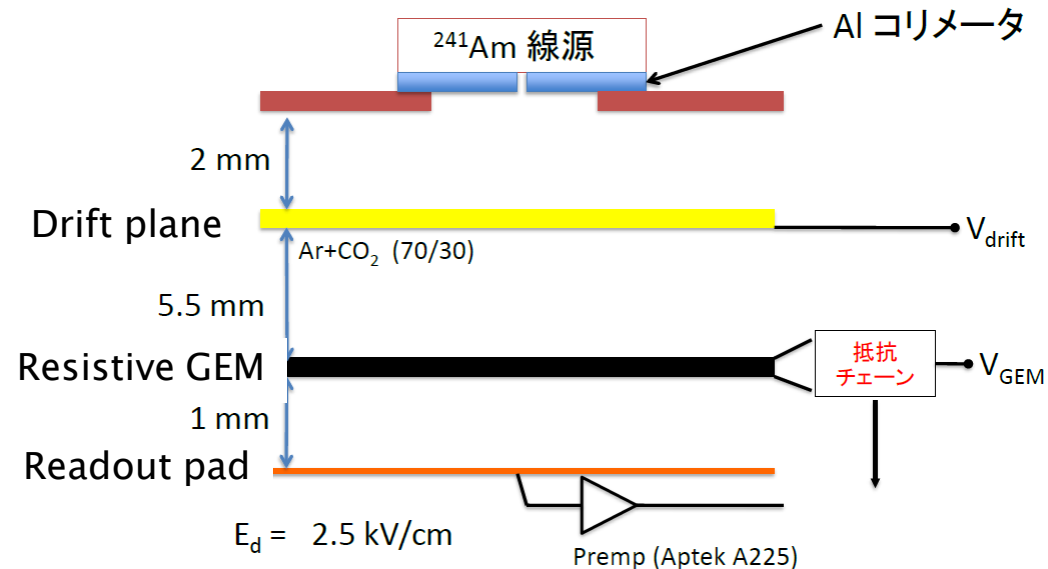
Structure of resistive GEM

- ▶ Processed by Scienergy
- ▶ Resistive kapton foils are attached on and under LCP sheet using bonding sheet
- ▶ Holes are drilled by laser
- ▶ Pitch of the hole : $140\mu\text{m}$
- ▶ Robustness for spark and lower amount of material are expect



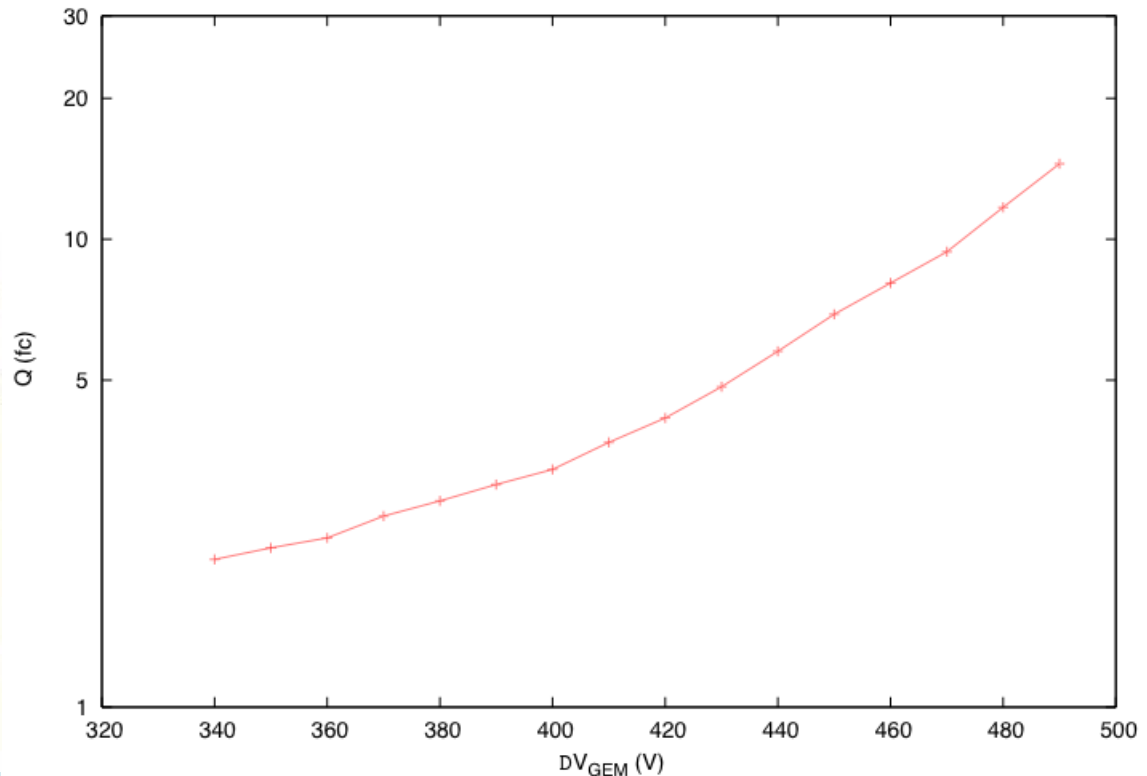
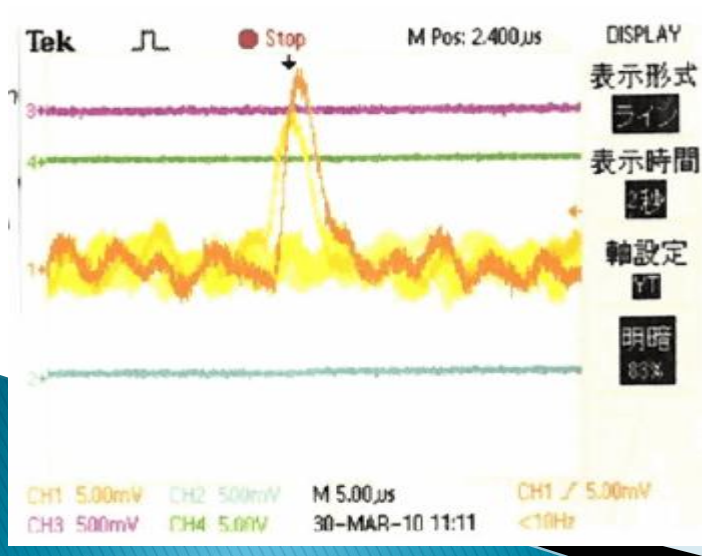
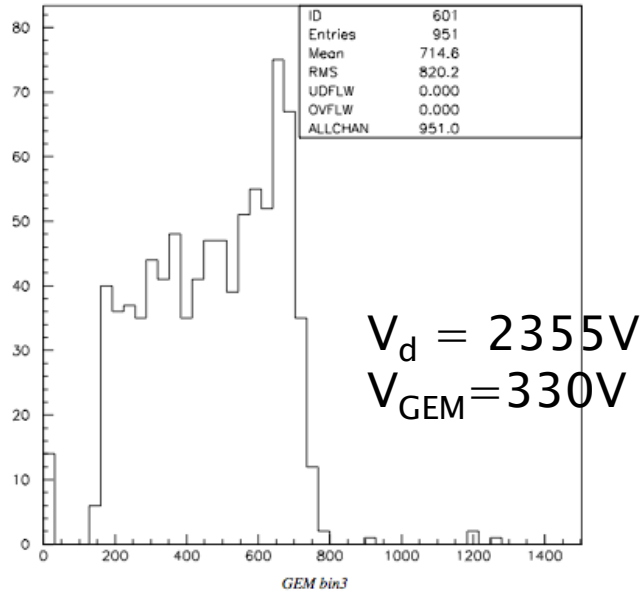
Setup for testing

- ▶ GEM area: 3cm x 3cm
- ▶ Resistivity between both resistive layers : a few T Ω .
- ▶ Operation voltage (V_{gem})
 - Up to 1000V when there is no source



Signal using ^{241}Am source

- ▶ Signal using ^{55}Fe will be test soon
- ▶ These results are very preliminary

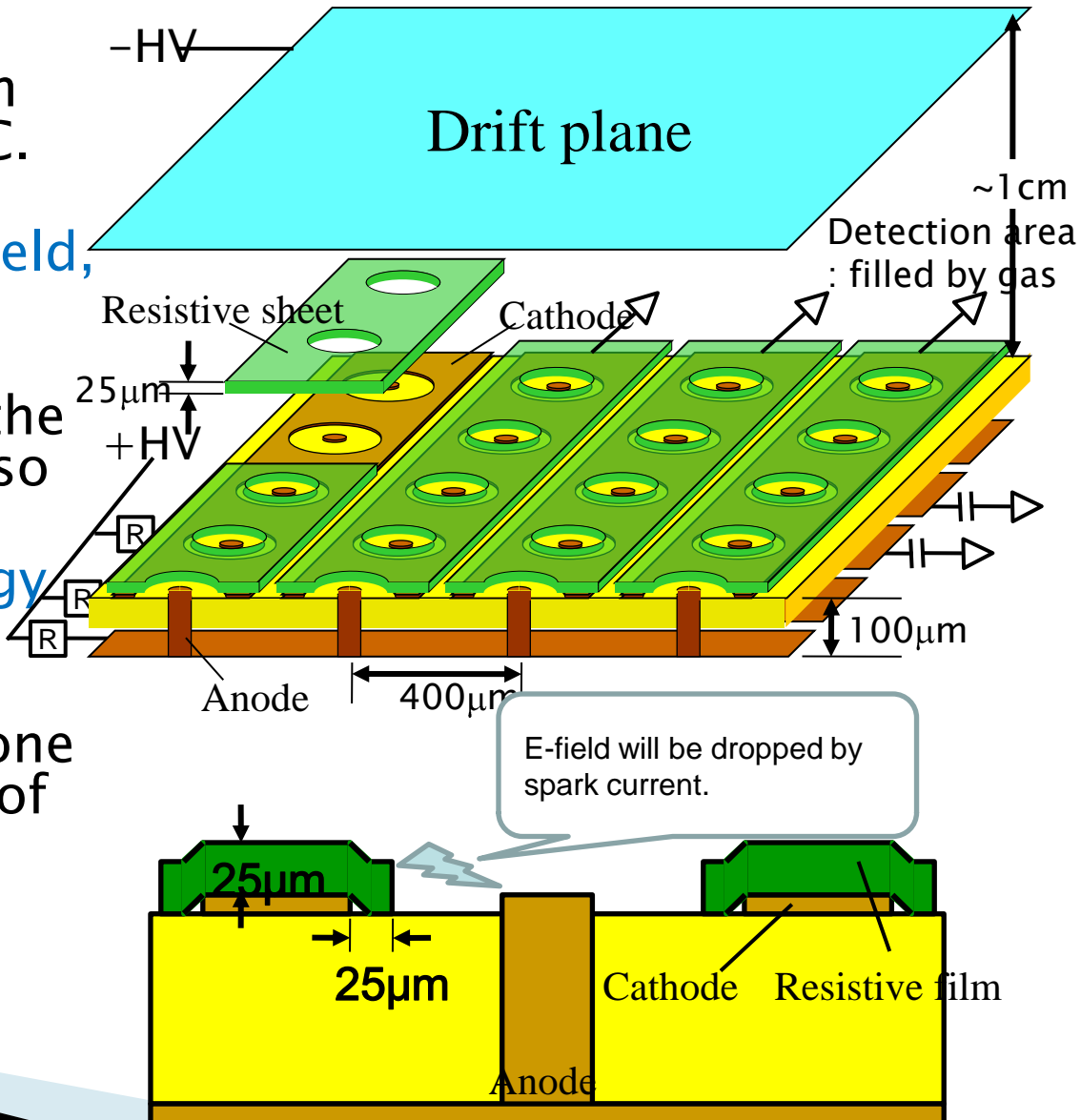


μ -PIC with resistive cathode

»» Kobe Univ.

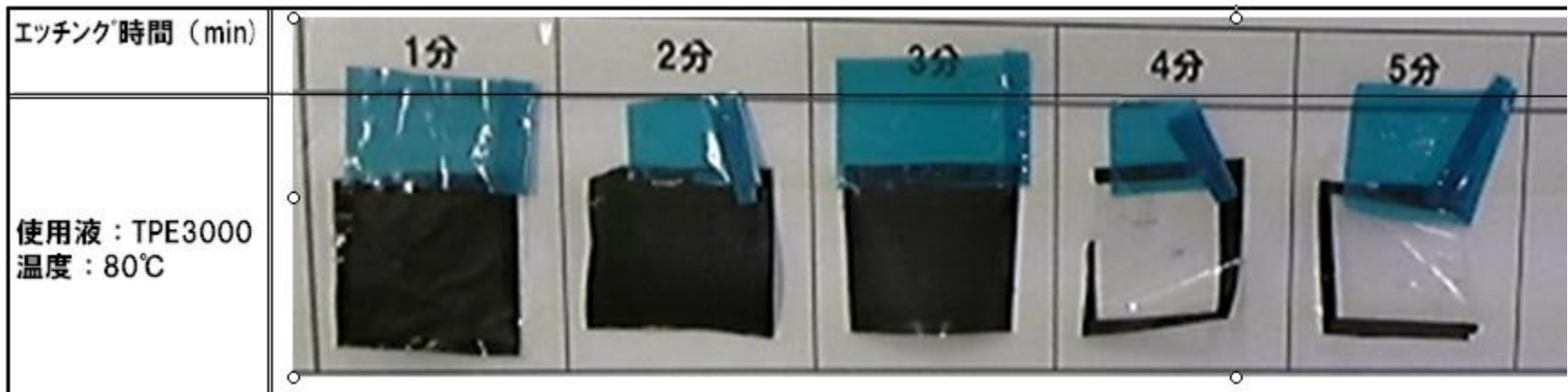
Structure of resistive μ -PIC

- ▶ Resistive kapton is on the cathodes of μ -PIC.
- ▶ Large current from spark reduce the e-field, and spark will be quenched.
- ▶ Huge signal beyond the “Raether limit” will also be suppressed
- ▶ Signal from low energy deposit will observed with higher gas gain
- ▶ This design provide one promised possibility of MIP detector under hadronic background



How to make?

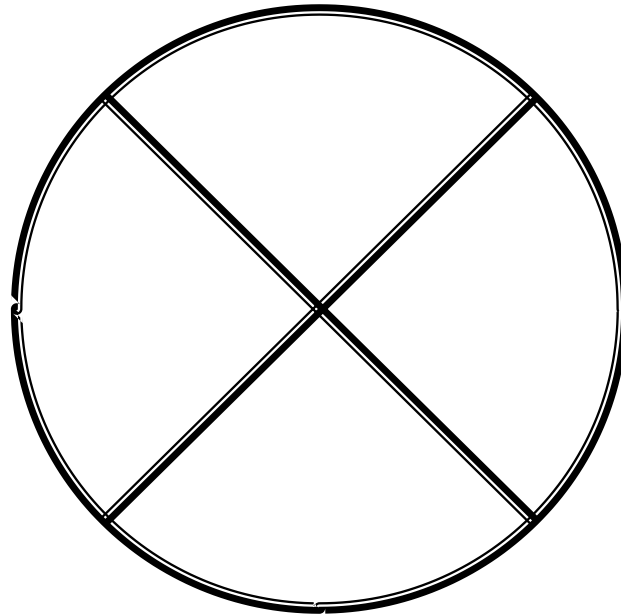
- ▶ There are two difficulty to use resistive kapton
 - How to make the fine micro pattern on resistive kapton?
 - We found how to etching the resistive kapton! (Raytech Inc.)



- How to attach the resistive kapton with conductive cathode?
 - At the first step, Cu foil is electroformed on resistive kapton using sputtering
 - Cathode pattern is processed on the resistive kapton, and attach it on the substrate.

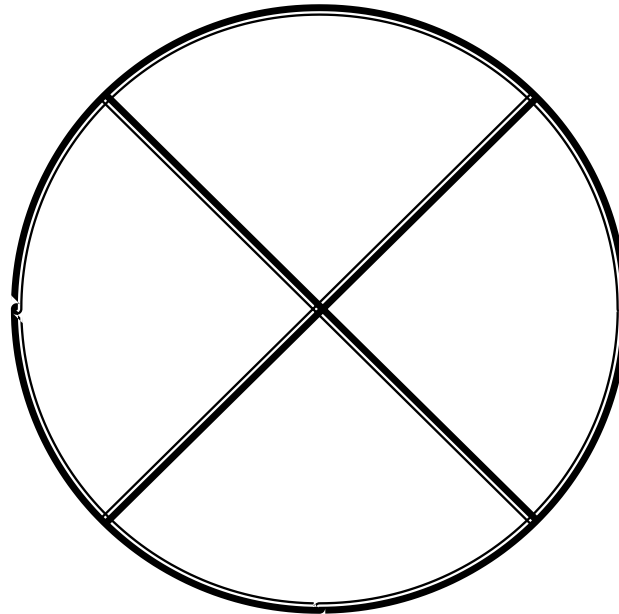
Process for re- μ PIC production

Supported by raytech-inc.



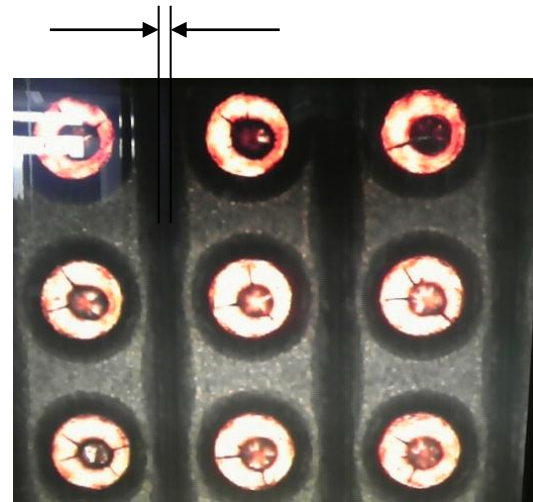
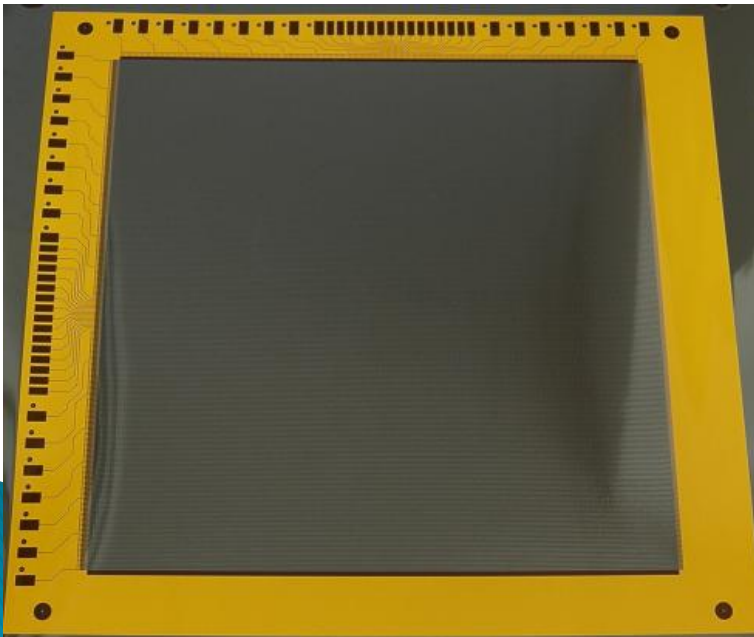
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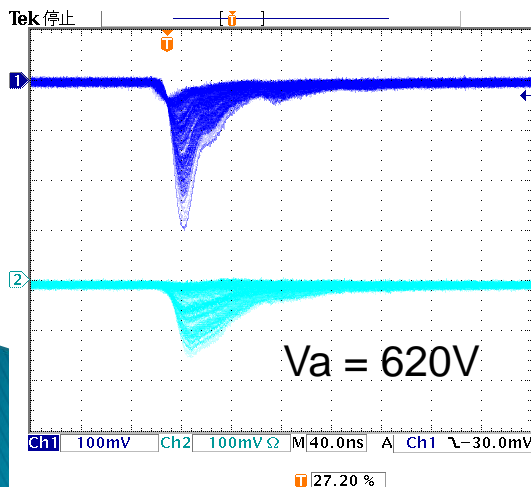
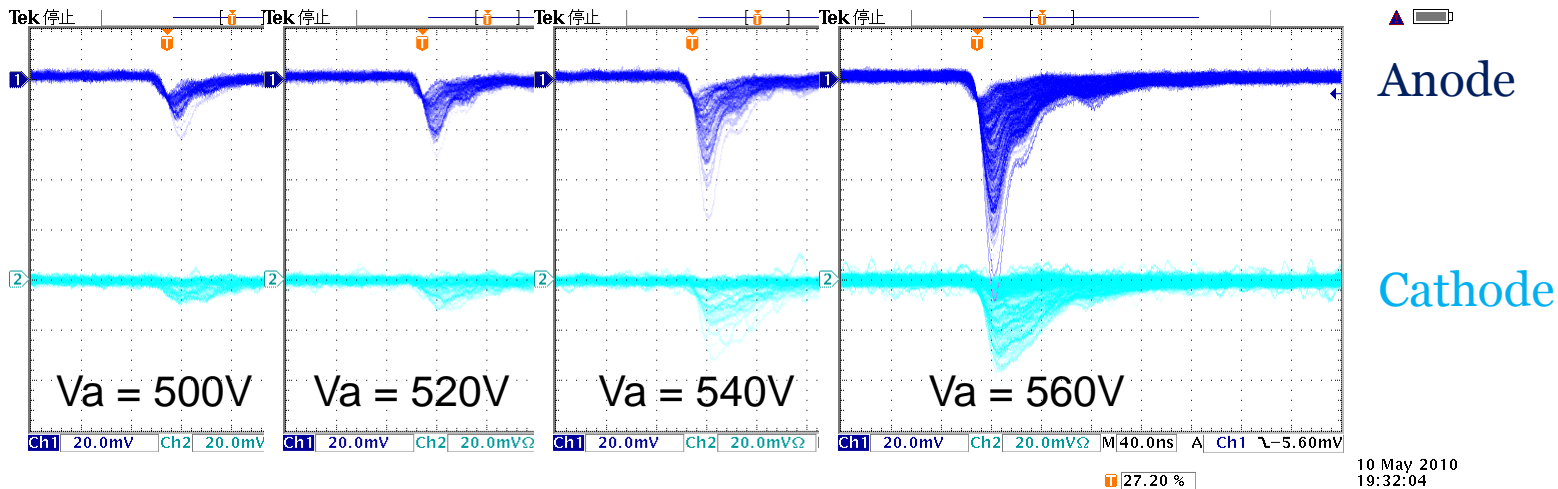


Setup for first prototype

- ▶ $V_d = 2\text{kV}$ ($2\text{kV}/\text{cm}$)
- ▶ $V_{ac} = 500 - 620\text{V}$
- ▶ Gas: $\text{Ar} + \text{C}_2\text{H}_6$
- ▶ $10\text{cm} \times 10\text{cm}$



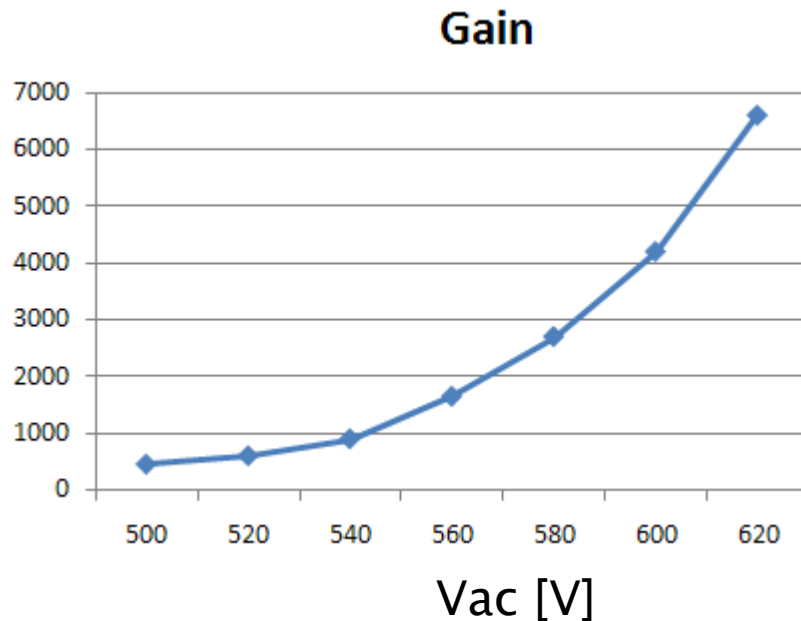
Signal using ^{55}Fe



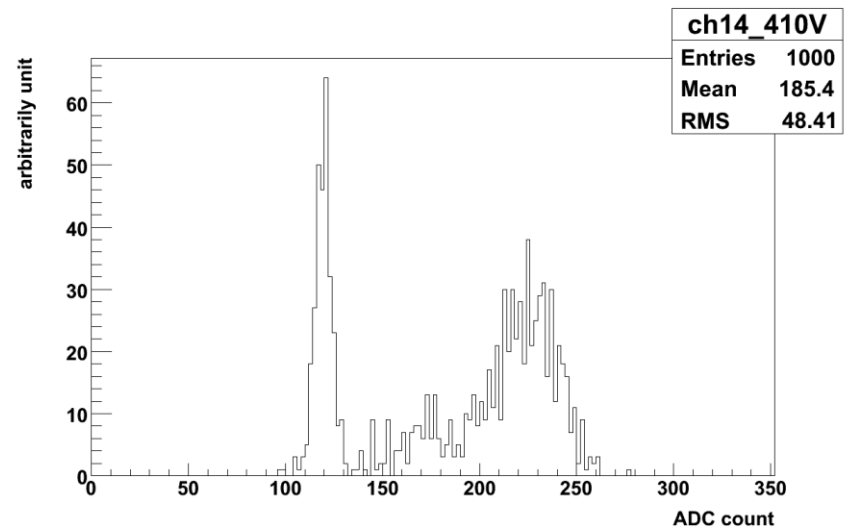
- ▶ **55Fe signals were observed using first prototype!**
- ▶ Estimated gain > 6000
- ▶ There is no energy resolution because signal is read from single strip

Gain curve and pulse distribution

- ▶ Very preliminary data



Pulse distribution
(using Ar 90%+ C₂H₆ 10% gas)



Summary

- ▶ MPGD with resistive kapton R&D has been started in JAPAN
- ▶ We have started 3 projects using resistive kapton
 - GEM readout with resistive kapton (KEK)
 - Charge up is avoided on the substrate,
 - good 2-dimensional readout
 - GEM electrode using resistive kapton (RIKEN/CNS)
 - Success to laser drilling process (SciEnergy co.ltd)
 - Signal observed using ^{241}Am
 - μ -PIC with resistive cathode (Kobe Univ.)
 - Success to etching process (Raytech inc.)
 - Signal observed using ^{55}Fe
- ▶ We need to improve the production quality, but principle is established
- ▶ We would like to thank to Rui de Oliveira
For providing material and fruitful discussions